MOBILE COMMUNICATION NETWORK AND METHOD OF OPERATION THEREOF

Field of the Invention

The present invention relates to a mobile communication network (particularly but not exclusively the Global System for Mobile communication (GSM) network) comprising a group of cells associated with a simulcast carrier and to a method of operation of such a network.

Background of the Invention

In a cellular mobile communication system each of the mobile stations communicate with a typically fixed base station. Communication from the mobile station to the base station is known as uplink and communication from the base station to the mobile station is known as downlink. The total coverage area of the system is divided into a number of separate cells each covered by a single base station. The cells are typically geographically distinct with an overlapping coverage area with neighbouring cells. As a mobile station moves from the coverage area of one cell to the coverage area of another cell, the communication link will change from being between the mobile station and the base station of the first cell to being between the mobile station the base station of the second cell. This is known as a handover..

Specifically, some cells may lie completely within the coverage of other larger cells. These are known as hierarchical cells and an example is so called microcells which are used to provide a high traffic capacity in high traffic areas. Typically the microcells are small and a large number of cells can be implemented in a limited area. A mobile station moving into the microcell will

be handed over from the overlaying cell, known as the macrocell. This frees up resource at the macrocell and hierarchical cell thus provide the possibility of a large coverage area combined with high traffic capacity.

All base stations are interconnected by a fixed network. This fixed network comprises communication lines, switches, interfaces to other communication networks, various controllers required for operating the network and the base stations themselves. A call from a mobile station is routed through this network to the destination specific for this call. If the call is between two mobile stations of the same communication system the call will be routed through the network to the base station of the cell in which the other mobile station currently is. A connection is thus established between the two serving cells through the network. Alternatively, if the call is between a mobile station and a telephone connected to the Public Switched Telephone Network (PSTN) the call is routed from the serving base station to the interface between the cellular mobile communication system and the PSTN. It is then routed from the interface to the telephone by the PSTN.

A simulcast system is one in which all the cells within an area transmit an identical signal, at the same frequency, at all times. This broadcast signal contains control information and is used as a beacon to determine relative signal strength. Additionally, each cell within the simulcast system can transmit a second frequency upon which traffic can be relayed. The second frequency is different from cell to cell although it may be reused if there is sufficient distance to mitigate interference. As a mobile is likely to remain within this simulcast system during the period of a call and the simulcast carrier effectively creates a single larger umbrella cell, very few intercell (between simulcast cells and external cells) handovers will be required. Consequently, the majority of handovers will be of the intracellular (between the simulcast cells) type. Since there is a single umbrella cell identification the mobile cannot identify the smaller target cells beneath this umbrella cell: i.e. the handover process cannot be mobile assisted i.e. based on the mobile

station differentiating between broadcast carriers. Rather than mobiles identifying cells, the cells identify the target mobiles by making measurements of the strength of neighbour uplink traffic. The stronger the neighbour measurement compared to measurements made by other cells the more probable that the observed mobile will handover into that cell.

The cells can be microcells or picocells for example. Picocells are commonly used inside buildings (where radio propagation through the external walls or internal partitions in the 900 MHz or 1800MHz bands is severely attenuated by metal structures for example) and microcells are commonly used in somewhat larger regions such as city centres for example.

In order to make measurements of the mobile stations in the surrounding simulcast cells the base stations will retune to the frequencies of the traffic carriers in these cells. However, as the frequencies are reused the base stations will measure a combined signal level of the desired mobile station and all mobile stations allocated the same time slot in cells using the same traffic carrier frequency. This may lead to inaccurate measurements and degraded handover performance.

Summary of the Present Invention

One object of the invention is to overcome or alleviate such a disadvantage.

More generally, the invention provides additional flexibility in a mobile network and enables more information to be obtained about the state of the network, as will become apparent.

According to a first aspect of the invention, there is provided mobile communication network comprising a group of cells with a common simulcast

carrier carrying signaling information, at least a first cell being associated with a first traffic carrier, wherein at least a first mobile station is arranged to intermittently perform an intracell handover to the common simulcast carrier, and means for performing measurements of the radio environment when the mobile station is using the common simulcast carrier.

In one embodiment the intracell handover is from the first traffic carrier to the common simulcast carrier.

According to a feature of the invention a clock means is arranged to generate a signal instructing said intracell handover and said clock means is located in a fixed part of the network and is arranged to transmit said signal to one or more mobile stations.

In one embodiment a signal instructing said intracell handover is arranged to be generated in response to a measurement of received signal level or quality of a radio transmission from a mobile station.

According to a different feature of the invention, one or more base stations are arranged to measure a received signal level and/or quality of the signal transmitted by the mobile station on the common simulcast carrier and a handover is determined in response to the measurements.

In one embodiment the mobile communication network is a GSM network.

According to a second aspect of the invention, there is provided a base station operating in a communication system having a group of cells with a common simulcast carrier carrying signaling information and at least a first cell being associated with a first traffic carrier, the base station comprising means for directing a mobile station to intermittently perform an intracell handover to the common simulcast carrier i, and means for performing measurements of

the radio environment when the mobile station is using the common simulcast carrier.

According to a third aspect of the invention, there is provided a method of operating a mobile communication network with a group of cells (2) with a common simulcast carrier carrying signaling information and at least a first cell being associated with a first traffic carrier, comprising the steps of: intermittently performing an intracell handover of a first mobile (4,4') station to the common simulcast carrier, and performing measurements of the radio environment when the mobile station (4,4') is using the common simulcast carrier.

Brief Description of the Drawings

A preferred embodiment is described below by way of example only with reference to Figures 1 and 2 of the accompanying drawings, wherein:

Figure 1 is a schematic diagram of a GSM mobile communication network in accordance with this invention, employing a simulcast BCCH carrier which extends over a group of picocells or microcells;

Figure 2 is a timeslot:frequency diagram of a base station in the network of Figure 1.

Description of a Preferred Embodiment

Referring to Figure 1, the GSM network illustrated comprises a group of picocellular heads 1 defining respective picocells 2, each picocell 2 representing the coverage of a respective broadcast carrier signal associated

with each picocellular head. Associated with each of the picocellular heads is a traffic carrier, each traffic carrier having a different frequency from those of at least its nearest neighbouring picocells.

A further simulcast carrier is transmitted from each picocellular head 1 and extends over all the above picocells as illustrated at 11.

The above group of picocells interfaces with in this case two macrocells 3 defined by carriers transmitted from base transceiver stations 8, which are in turn linked by fixed communications links to a common base station controller 9 and thence to the rest of the network. In a variant, the picocells 2 could be microcells and an umbrella cell could overlie the picocells or microcells.

In operation, a control signal generated e.g. by a clock 10 and transmitted over the fixed communications links or alternatively generated in response to a detection of radio signal level and/or quality below a predetermined threshold is broadcast to a mobile station 4 and (as indicated by radio signal 5) instructs the mobile station to perform an intracell handover to an uplink carrier frequency and timeslot corresponding to the simulcast carrier. Such a signal 5 could also be transmitted by a picocellular head 1' to a mobile station 4' as illustrated, the change in frequency being represented by arrow 7.

The structure of signal 5 will now be described in more detail with reference to Figures 2 before describing the response of the mobile stations 4 and 4'.

Figure 2 shows the frequency:timeslot distribution of the various signals transmitted by a base transceiver station (BTS) 8 to its associated macrocell or by a picocellular head 1 to its associated picocell. The group of frequencies (or more accurately frequency bands) f_1 to f_5 available to a given (macro or pico) cell will typically not include any frequencies in common with those used by neighbouring cells, in order to avoid interference. In other respects the

frequency:timeslot distributions of the respective macrocells and picocells are similar.

The carrier is transmitted in slot SL corresponding to timeslot 0 and frequency f_5, the beacon frequency. The carrier comprises the FCCH, SCH, BCCH, PCH and AGCH channels which carry respective types of control and information data to the mobile stations within the cell, as defined in the GSM specifications. In order to ensure that the most powerful transmission is on the beacon frequency (to enable it to be identified by mobile stations within the cell in order to enable them to access the above control and information data) any slots not used on frequency f_5 are filled with dummy bursts.

The above frequency:timeslot structure is conventional in GSM mobile communication networks. It is now assumed that a call has been established to or from a mobile station within a cell of interest. The mobile station will be communicating using a timeslot TS1 on the traffic carrier frequency of the corresponding picocell. The signal 5 will be carried to the mobile station through a control channel in the time slot SL, for example on the FACCH (Fast Associated Control Channel). The signal 5 will result in the mobile station changing to a time slot TS2 on the BCCH frequency.

Having described the intracellular handover of a mobile station to a new traffic channel on the BCCH carrier, the resulting operation will now be described further with reference to Figure 1. There are a number of choices.

Firstly it will be noted that the timeslot TS1 previously used by the picocellular head 1' to transmit traffic to the mobile within its picocell is no longer used, since this function has been taken over by the radio unit responsible for the simulcast transmission. Accordingly the transceiver (not shown) associated with the picocellular head 1' can be retuned to another frequency during this timeslot and used to make e.g. interference measurements or measurements of mobile station signal level and/or quality

on that frequency. For example a mobile station communicating in a time slot TS3 on the traffic frequency f1 of the neighbour picocell can be measured by changing the receive frequency from f2 to f1 during time slot 6. Alternatively, the receiver can continue to receive on the same frequency f2 and thus measure the interference level in the absence of the mobile station. This information can then be passed back up to a base station controller 9 and thence to an appropriate part of the fixed network controlling frequency allocation between cells or picocells. A similar procedure could be followed by a base transceiver station 8 associated with a macrocell 3 (or with a microcell, not shown).

Secondly all the picocell transceivers within the coverage 11 of the simulcast BCCH can be arranged to measure the signal level from the mobile station as they all have the BCCH carrier frequency f5 in common. This information can then be used to select the neighbouring picocell 2 receiving the highest power and/or signal quality for intercellular handover as the mobile station approaches that picocell. This is a desirable facility because the conventional method of cell selection for intercellular handover, involving downlink measurements by mobile stations, the results of which are transmitted to the base transceiver stations, can result in ambiguity as a result of two mobile stations in no-neighbouring picocells but within the simulcast coverage area 11 transmitting on the same frequency. Difficulties can also arise when the mobile stations are fast-moving - e.g. in trains.

Preferably, the mobile station will return to a traffic carrier following the measurements. However, this traffic carrier can be that of a different picocell if the measurements indicate that that will result in better performance.

According to one feature of the invention the signal 5 is generated by a clock which for example periodically instigates a new measurement. The clock can be located centrally in the network and can be distributed through the fixed network to the appropriate picocell heads for transmission to the mobile

stations. Alternatively, the process can be instigated in response to measurements of the current radio transmission. Information of interference levels and possible transmission quality for neighbour base stations is of most importance when the current transmission quality is unsatisfactory and a hand over is required for improved quality. For example, if a mobile station has an unsatisfactory quality level for the current serving picocell it can be instructed to handover to the BCCH carrier where all picocell will be able to measure the signal level from the mobile station. A handover to a given picocell head can then be determined in response to these measurements. Preferably by selecting the picocell which receives the strongest signal level from the mobile station.

The measurement process can thus be instigated in response to a measurement of the signal level or quality of the current transmission. Preferably, the measurement process would be instigated when these levels fell below a given threshold.

According to a feature of the invention the measurements are repeated for a number of mobile stations thereby building up information of the distribution of mobiles within the network.

In a variant of the above embodiment, a mobile station is temporarily assigned to a slot of the simulcast carrier when it originates a call. Uplink measurements similar to those described above are then made at the picocellular heads (or at base transceiver stations associated with microcells) and an appropriate picocell or microcell is assigned to the mobile station on the basis of such measurements. In this embodiment the intracellular handover is thus not from another traffic carrier but rather from a non-active state.

Although an embodiment of the invention has been described in the context of a GSM mobile cellular communication network, it should be noted that the

invention is not restricted to such a network but that it is also applicable to other mobile cellular networks such as the NADC network in the USA and the PDC network in Japan.